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Abstract:
This paper considers the processing of an important class of spatial lexemes — called Internal Localization Nouns (ILNs) — which are used for designating the different parts of entities. It is grounded on a detailed linguistic analysis of the studied lexemes in terms of geometrical, functional and contextual/pragmatic properties. The experiment described in this work mainly focuses on ILNs calling for orientation notions. It consists in a pointing task which makes systematically vary the geometrical and functional properties of entities as well as the position in which they are displayed. The impact of these changes in the interpretation is evaluated through the measurement of response latencies. This protocol provides interesting data on the part played by several complex parameters — such as gravity, geometrical and functional saliency, motion, canonical use etc. — in the processing of orientational ILNs.

Key-words: processing of spatial expressions, Internal Localization Nouns, orientation, pointing task.

Résumé :
Cet article porte sur le traitement d'une classe importante de lexèmes spatiaux — appelés Noms de Localisation Interne (NLI) — utilisés pour désigner les diverses parties d'une entité. Il repose sur une analyse linguistique détaillée des lexèmes considérés, en termes de propriétés géométriques, fonctionnelles et pragmatiques. L'expérimentation présentée ici se focalise, pour l'essentiel, sur des NLI faisant appel à des notions d'orientation. Elle consiste en une tâche de pointage faisant systématiquement varier les propriétés géométriques et fonctionnelles des entités ainsi que la position dans laquelle celles-ci sont présentées. L'impact de ces changements sur les processus interprétatifs est évalué à travers la mesure des temps de réponse. Ce protocole fournit des données intéressantes concernant le rôle joué par plusieurs paramètres complexes — parmi lesquels la gravité, la saillance géométrique et fonctionnelle, l'usage canonique, le déplacement, etc. — dans le traitement des NLIs orientationnels.

Mots-clés : traitement des expressions spatiales, Noms de Localisation Interne, orientation, tâche de pointage.

1 Aims, methods, hypotheses

1.1 The semantics of Space: Internal Localization Nouns

1.1.1 Internal Localization Nouns and part/whole relations

This study investigates spatial expressions which display use of Internal Localization Nouns (henceforth, ILNs), i.e. lexical items which refer to a portion of an entity as opposed to a whole entity (ex: *haut* (top), *avant* (front), *bord* (edge), *intérieur* (interior/inside), *angle* (corner), etc.). Due to their nature per se, these lexical items are included in a more general framework which accounts for relations between a part and a whole entity or meronomies. In recent years, part-whole relations gave rise to many studies both in linguistics, psycholinguistics, philosophy of language and artificial intelligence (Cruse, 1986; Guarino et al., 1994; Iris et al., 1988; Moltmann, 1994; Pribbenow, 1995; Tversky, 1986, 1990; Winston et al., 1987). Although these studies often mention ILNs among the different linguistic tools intended to point out parts of entities, few detailed analyses of these markers have been carried out so far. This lack of detailed works on ILNs is even clearer if one considers the purely substantival uses of these markers (*le haut de la porte est sale* (the top of the door is dirty)) rather than their integration in a prepositional phrase (*à l'intérieur de* (at the interior/inside of), *au bord de* (at the edge of), etc.).

Indeed, an indepth study of ILNs shows that they have very precise semantic and morphosyntactic properties and, consequently, constitute an homogeneous and specific class of linguistic markers (Aurnague, 1989, 1996; Borillo A., 1988).

The parts of entities which are designated by ILNs display fuzzy boundaries and do not fulfill precise functions in the whole entity. They are distinguished on the basis of these two features — namely function and geometrical delimitation — from parts which appear in the category "component-assembly" (*pied* (leg), *roue* (wheel), *tiroir* (drawer), *toit* (roof), etc.) (Pribbenow, 1995; Vieu, 1991). The analysis of ILNs in French and

Basque has shed light on additional syntactico-semantic criteria which characterize these lexical items and distinguish them from component nouns (Aurnague, 1996). This contrastive study of ILNs and nouns of components demonstrated that beyond a strict opposition between these two categories, a full continuum emerges, most ILN diachronically deriving from nouns of components. Somehow, this fact confirms the hypothesis of Svorou (1994) according to whom linguistic markers of space would come from three main sources: human body parts (anthropomorphic model), animal body parts (zoomorphic model) and referents of the environment.

1.1.2 ILNs: a polarized system

Although the semantics of nouns of components include information regarding the function the part perform in the whole entity, they do not provide any precise information regarding the localization of this part. In order to localize a component, a listener is expected to know the precise layout of the whole entity (Borillo A., 1988). On the other hand, the semantic content of ILNs often indicates the localization of the considered part in relation to the whole entity. Thus, when exposed to an ILN, a listener is able to identify the area of the whole entity which is being referred to. The parts defined by an ILN in a whole entity are indeed organized in a system of contrastive/opposite localizations. This is particularly obvious in the case of orientational ILNs which designate two by two opposed locations arranged according to three main axes (Franklin & Tversky, 1990): vertical (*haut* (top)/*bas* (bottom)), frontal (*avant* (front)/*arrière* (back)) and lateral (*gauche* (left)/*droite* (right)). The same pattern of opposition between zones or poles emerges when observing ILNs which refer to topological notions. The ILNs *intérieur* (interior) and *fond* (bottom/back/base) are typically contrasted with those that point out the exterior/outside zones as well as the boundaries/limits. In fact, a linguistic distinction between various levels of boundaries can be drawn (surfaces or boundaries of volumic entities: *côté* (side), *face* (side/face), *surface* (surface), etc.; lines or boundaries of surfaces: *bord* (edge), *rebord* (rim/edge), *pourtour* (surround), *angle* (corner), etc.). Finally, ILNs — the semantics of which relies on notions of distance — introduce a contrast between the parts found in the center/middle of the whole entity and those located at the edge and/or at the ends/extremities.

So, the layout of space defined by ILNs is based on 3 types of notions: topology, orientation and distance. We are referring here to a "natural" or "cognitive" geometry as opposed to classical geometry (Herskovits, 1986; Talmy, 1983). Besides, ILNs do not solely resort to geometrical notions; they also involve numerous functional properties (for instance, it is the case of both the orientation and the concept of "containment" which underlies the definition of interior/inside (Vandeloise, 1986)) and contextual/pragmatic factors (Aurnague & Vieu, 1993). Some of the stimuli used in the experiment presented below aim at testing the contribution brought by ILNs' functional and pragmatic aspects to their semantics.

A preformal analysis of French ILNs has led us to describe the functioning of these lexical items in terms of semantic features (Aurnague, 1989). The notion of " feature " in this context is very close to that found in phonology: it is a minimal item which is able to fulfill a distinctive function at the semantic level between several ILNs. Among the features, some refer to orientational properties (oriented axes, deictic/intrinsic orientation) while others account for topological/morphological aspects (dimension, consistency, interior, boundary, shape) or pertain to the domain of distance (middle, end/extremity). On the basis of these descriptions in terms of features, we tried, in a second phase, to introduce formal definitions for some ILNs. These definitions call for tools from first order logic and enable us to carry out a more precise analysis of the semantic content of these lexical items (Aurnague, 1991, 1995).

As already underlined, ILNs — and more particularly substantival uses of these markers — have so far given rise to very few descriptive and/or formal researches. However, the analysis of dimensional adjectives (*high, long, thick,* etc.) proposed in (Carstensen & Simmons, 1991; Lang, 1990; Lang & Carstensen, 1990) seems to call for conceptual domains (topology, orientation, relative distance) which are quite similar to what we introduce in our own study of ILNs. Nevertheless, the different nature of these classes of markers also entails that the particular notions (of each domain mentioned above) involved in the two studies are quite distinct. Indeed, ILNs call for several topological notions (especially different kinds of boundaries) which seem not to be involved in the semantics of dimensional adjectives and the orientational notions underlying these two kinds of markers do not always coincide. Another difference lies in the fact that, apart from the role of gravity, the analyses of dimensional adjectives previously mentioned are mainly grounded on geometrical properties and leave many functional and pragmatic aspects aside. In connection with this, Vandeloise (1988) showed that the semantics of dimensional nouns like *length* and *width* cannot be grasped through the only use of geometrical properties and heavily depends on functional notions such as motion or "potential passing".

The main aim of this psycholinguistic study is precisely to clarify the part of several functional and contextual/pragmatic factors in the processing of ILNs. Doing so, it should deepen and broaden the descriptive and formal analyses already available. It can also be viewed as a complement to other experiments on ILNs which have mainly focused on the geometrical and visual properties underlying the semantics of these markers (Van der Zee, 1996).

This deepening of the role played by functional and contextual parameters in linguistic space may appear as being in conflict with the psycholinguistic and computational analyses of spatial markers (mainly spatial prepositions) that manipulate "regions of acceptability" or "arrays" (Hayward & Tarr, 1995; Logan & Sadler, 1996). Although the regions handled in such theories seem to be grounded on purely geometrical properties, one can note that they are often associated with frames of reference whose characterization itself depends on the nature of the considered entities, that is to say on geometrical, functional or even contextual properties. Moreover, these approaches reveal that several functional features which play an important role in the functioning of spatial prepositions (e.g.: contact, support, etc.) cannot be grasped through the use of representations only relying upon geometrical regions (Logan & Sadler, 1996).

2. Experimental protocol

In general terms, and although some topological and distance aspects are also taken into account, the experiment presented hereafter focuses on several *orientational aspects* of ILNs. It aims at investigating how vertical, frontal and lateral axes are processed on both non-oriented and oriented objects and, in particular, at controlling for the effects of functional and contextual factors in the processing of ILNs.

2.1 Linguistic material and hypotheses

The part of function in the semantics of orientational ILNs has been tested by systematically comparing their application to functional entities with what occurs when they are associated with purely geometrical forms (lacking in function). As far as contextual aspects are concerned, we tried to grasp at best how changes in the positioning of a functional entity (with respect to its canonical position) may influence the processing of orientational ILNs. In what follows, we specify, for each orientational axis, the main functional and contextual points we tried to analyse and clarify. A more detailed account of the various assumptions which have been made is provided in the results section (3), when the different ILNs (and the stimuli selected to test them) are successively presented.

For the vertical axis, we observe the effects the positioning of a functional entity (having an intrinsic vertical orientation) produces on the processing of the ILNs *haut/bas* (top/bottom). We try, in particular, to seize at best how the dissociation of canonical vertical orientation (of the oriented entity) and gravitational vertical influences the orientational strategies followed by the subjects that is to say the choice between intrinsic (object-centered) and deictic (viewer-centered) orientations. This approach is very much akin to that developed in other works (Carlson-Radvansky & Irwin, 1993) which considered the way in which the positioning of the speaker with respect to gravitational vertical can influence the use of spatial relations (e.g.: *above*).

In the case of the frontal axis, we attempt to control for the influence of functional factors such as the layout of the parts of an entity (internal structure) or the notion of motion in the identification of *avant* (front) and *devant* (front surface). We assess, in particular, the validity of the assumption according to which the ILNs *avant/arrière* (front/back) are strongly related to the notion of motion contrary to *devant/derrière* (front surface/back surface) which seem not to depend so heavily on it.

Finally, we try to evaluate to which extent the nature of entities and the use one makes of them contribute to the determination of the parts identified by the ILNs *gauche* (left), *droite* (right) and *côté* (side). We mainly examine the processing of lateral orientation in situations that involve entities used in a " mirror " or " tandem " fashion[1]. More generally, this part of the experiment leads us to discuss several aspects of lateral orientations which have not been yet clarified (in the literature), and particularly, the precise characterization of the different strategies followed by the subjects, namely the opposition between a deictic (viewer-centered) and an intrinsic (object-centered) perspective[2] .

In summary, we specifically study:

a) *On the vertical axis*, the processing of the ILNs *haut* (top) and *bas* (bottom):

- for intrinsically oriented entities: a bottle (standing up: Fig. 1a, lying down: Fig. 1b, upside down: Fig. 1c))

- for non oriented entities, i.e. the orientation of which is deictic: a parallelepiped presented in different perspectives (standing up: Fig.1d, lying down: Fig. 1e)

b) *On the frontal axis*, the processing of *avant* (front) and *devant* (front surface) again for two types of entities:

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[1]A spatial entity is used in a mirror fashion by an individual if the (intrinsic) frontal orientation of the former is opposed to (faces) the (intrinsic) frontal orientation of the latter (e.g.: someone facing a cupboard). This situation contrasts with the so-called mirror configurations in which the frontal orientations of the user and the spatial entity coincide (they point towards the same direction; e.g.: someone sitting on a chair). These two strategies can also be used by speakers in order to assign a frontal orientation to spatial entities situated in front of them (deictic frontal orientation).

[2]Contrary to vertical and frontal orientations that have been extensively studied, some cases calling for a lateral orientation and in which a speaker is facing a spatial entity are difficult to characterize (intrinsic/deictic distinction). In particular, the configurations in which the lateral orientation of the speaker coincides with that of the spatial entity in front of her/him (someone facing a cupboard) do not seem to imply always a deictic orientation of the latter (see 3.3.1).

- for intrinsically oriented entities: a house (Fig. 2a), a dresser (Fig. 2b), a bicycle in different perspectives (profile: Fig. 2c, mirror: Fig. 2d, tandem: Fig. 2e)

- for deictically oriented entities: a parallelepiped (displayed in the same positions as above).

c) *On the lateral axis*,

c.1) the processing of the ILNs *gauche* (left) and *droite* (right):

- for intrinsically oriented entities: an armchair (Fig. 3a), a wardrobe (Fig. 3b).

- for deictically oriented entities: a standing up parallelepiped (Fig. 1d).

c.2) the processing of the different meanings/interpretations of the ILN *côté* (side):

- for entities having both vertical, frontal and lateral intrinsic orientations: a car (Fig. 3c)

- for entities having vertical but no horizontal (frontal and lateral) intrinsic orientation: an horizontal square section vase (Fig. 3d)

- for non intrinsically oriented entities: a dice (Fig. 3e).

2.2 Subjects

47 French-speaking subjects, between 18 and 59 years of age (mean age: 31.17), underwent the experiment. All of them were either students or staff members from the Université de Toulouse-Le Mirail; all of them were right-handed and without any visual problems. There were 18 males, between 18 and 52 years of age (mean age: 32.2), and 29 females, between 22 and 59 years of age (mean age: 30.5).

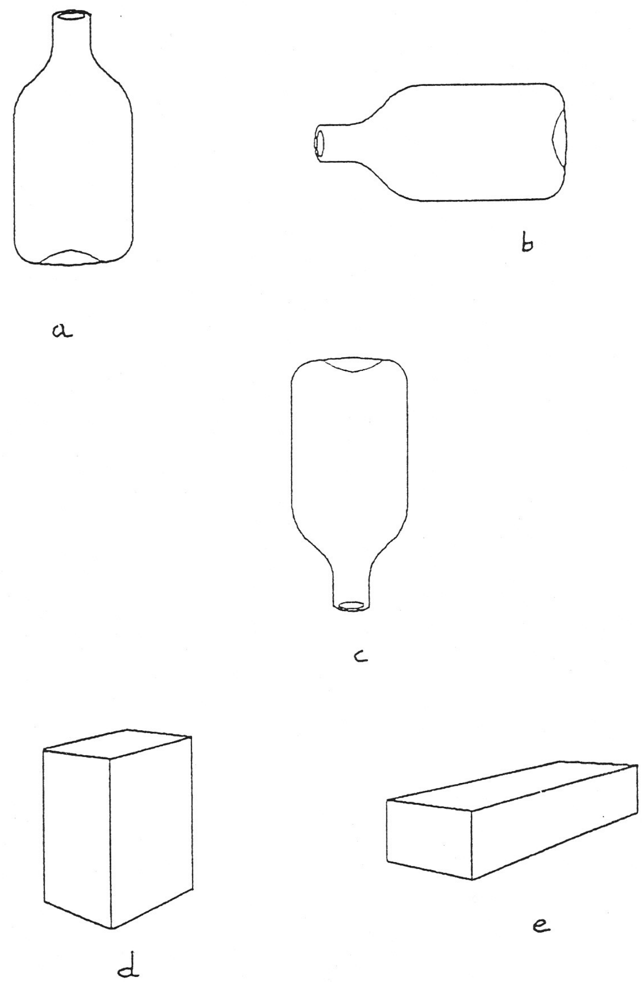

Figure 1. (a) bottle standing up; (b) bottle lying down; (c) bottle upside down; (d) parallelepiped standing up; (e) parallelepiped lying down

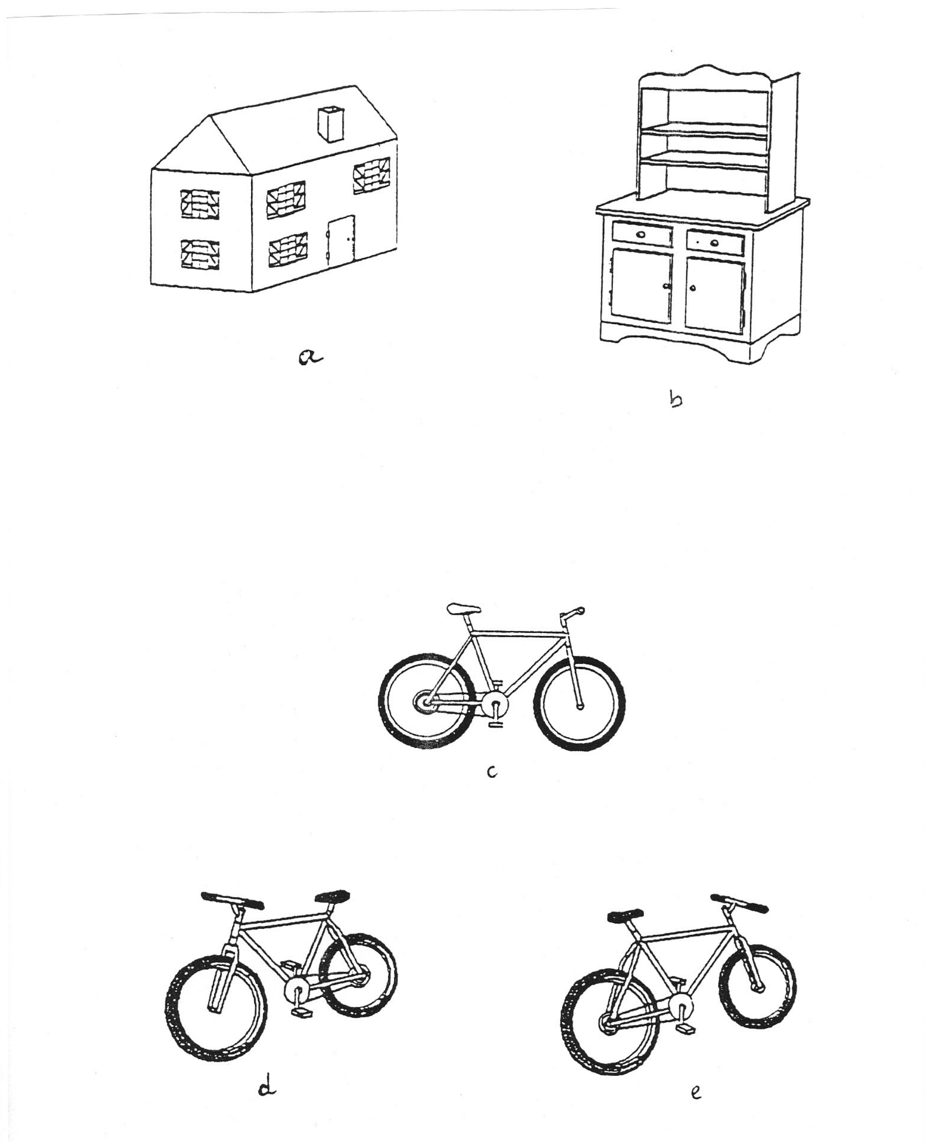

Figure 2. (a) house; (b) dresser; (c) bicycle profile perspective; (d) bicycle mirror-orientation; (e) bicycle tandem-orientation

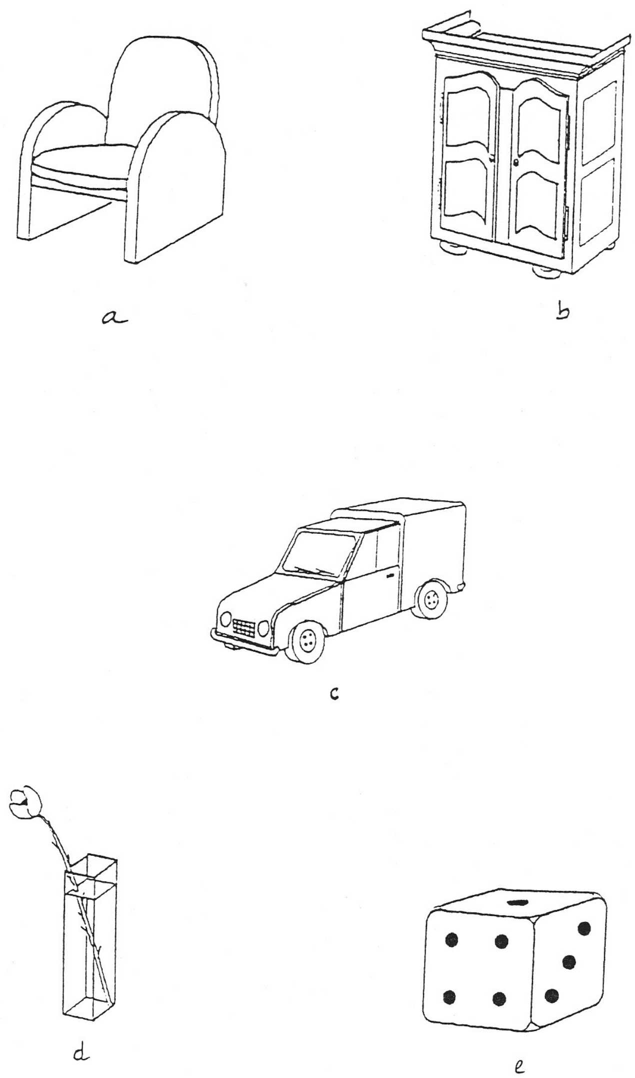

Figure 3. (a) armchair; (b) wardrobe; (c) car; (d) vase; (e) die

2.3 Experimental procedure: a pointing task

All subjects for this study underwent a pointing task in two parts.

In Part I of the experiment, they were presented simultaneously with both a picture (e.g. a bottle) and a word deprived from any article (e.g. *haut* (top)) on a Macintosh tactile screen. Each stimulus was presented only once. From a fixed spot on the table (located at 25 cm from the lower part of the screen), they were asked (a) to point, as quickly as possible, with their finger, to the part of the object corresponding to the word and (b) to put back their finger on the spot straight away after. The following stimulus automatically appeared on the screen two seconds after each hit. All stimuli were presented to the subjects in a randomized order, different for each subject.

X/Y positions of the hits on the tactile screen were recorded. Latencies were recorded between the presentation of the stimulus and the moment when the finger hit the screen. Now, since obviously such latencies corresponded to different underlying processes — i.e. visual information intake + decision itself + finger displacement time — the subjects, straight away after completing the first part of the experiment, were asked to undergo a second subtest in which they were presented with 1cm square targets appearing on the screen precisely where the finger hits had taken place in the first part of the experiment. Subjects were again asked to point as quickly as possible to such targets. Through such an elementary pointing task, it was thus possible to subtract displacement time from the global latency. Thus, response latencies presented in the Results section of this paper consist in the product of the subtraction " Global latency — displacement time[3] " per stimulus.

In order to ensure that the subjects had correctly understood what they had to do in the two parts of the experiment, a preliminary set of five stimuli was presented for each subtest before the beginning of the experiment proper.

Further remarks have to be made concerning both the linguistic expressions and the

[3] which is, of course, highly variable from one stimulus to another, the geometrical properties of the drawings being themselves different.

graphical representations of entities which are presented to the subjects.

Reducing the linguistic message to a single ILN can, at a first sight, appear somewhat unnatural. However, if one wants to grasp precisely the part of functional properties of spatial entities as well as the role of contextual factors (such as positioning) in the cognitive processes underlying the interpretation of ILNs (considering, in particular, the choice between deictic and intrinsic interpretations), then it becomes necessary to minimize, as much as possible, the influence of other linguistic markers (e.g.: spatial prepositions and verbs) on this interpretation process. Indeed, the use of more complex linguistic utterances (although more "realistic") would not allow to distinguish the factors involved in the interpretation of ILNs that are related to the functional and contextual properties under study and those which are entailed by other linguistic markers to be found in the message. Making such a distinction would suppose to have a very powerful theory of linguistic space which, as far as we know, is not currently available.

For similar reasons, our decision to test the influence of functional properties of spatial entities and contextual parameters on the way ILNs are interpreted led us to display representations of entities where only these aspects are changing and to leave aside other graphical elements which could have forced the subject towards a particular interpretation.

Even if the possibility of a choice between several interpretations (that mainly occurs with functional entities) can appear partly problematic for the analysis of our results, the presence of geometrical shapes which usually give rise to deictic interpretations of ILNs provides us with some kind of "calibration" of purely deictic processes. From this point of view, geometrical objects can be seen as constituting "reference stimuli" in the experiment. In any case, it is most likely that the results entailed by our experimental design are quite different from those that could be obtained in a situation in which the subjects would have been always forced to make a given choice.

3. Results

In this section, results relating to data on vertical, frontal and lateral axis are successively examined. For each axis, we mention, in a brief introduction, the specific issues that are examined; then, results are presented together with the comments that may be derived from them.

3.1 Vertical axis and the non-canonical positioning of entities

3.1.1 Introduction

Gravity is known to be crucial to the linguistic expression of space. It is indeed involved in the semantics of various orientational markers among which we find a few ILNs (*haut* (top), *bas* (bottom), *dessus* (top surface), *dessous* (underside)) and prepositions (*sur* (on), *au-dessus de* (above), *au-dessous de* (below)) . It is also an important component of the notion of "containment" (together with opposition to lateral movements) which underlies the way the preposition *dans* (in) functions (Vandeloise, 1986; Vieu, 1991). The relevance of gravity is confirmed by the fact that in the process of first language acquisition, vertical orientation is first mastered by children followed by frontal and lateral orientations (Piérart, 1979). However, many points still need to be clarified regarding the way speakers/hearers handle this notion. Like for other types of orientation, the determination of verticality depends on the reference framework which they select. The speakers may refer to the intrinsic vertical axis of an entity, which derives from the functional properties and the use we make of it. They can use the context by referring to a gravitational vertical. They can also make use of their own body reference framework and thereby adopt a deictic strategy. In the particular case of vertical orientation, deictic and contextual frameworks often coincide since speakers usually find themselves in the human canonical position, that is standing up on the ground. Some experiments which allow for a dissociation between deictic and gravitational vertical (ex: subject lying on a sofa) have demonstrated that speakers most often resort to deictic uses when those overlap with contextual uses, that is when they are standing up (Carlson-Radvansky & Irwin, 1993; Friederici & Levelt, 1990). The experimental conditions and the relative overlap between deictic and contextual reference frameworks have therefore led us to focus on the processing of the intrinsic/deictic opposition in vertical orientation . Indeed, it was important to test the strategies adopted by the subjects when those two frameworks trigger distinct or even opposite choices. In order to do so, a few stimuli relating to ILN *haut* (top) and *bas* (bottom), in which a same entity is depicted in different positions, have been introduced. The functional entity selected for this test is a bottle depicted in three positions (Figs.1a, 1b, 1c). Some stimuli relating to the same ILN and displaying features deprived of functional entities — that is purely geometrical shapes (parallelepiped) — have also been considered (Figs. 1d, 1e).

3.1.2 Results

Table 1
Vertical axis: ILNs *haut* (top) and *bas* (bottom). Mean response latency and number of responses (IT = intrinsic, DT = deictic, EL = eliminated)

ENTITY	ILN	IT		DT		EL
		Number	R.T(ms)	Number	R.T(ms)	Number
Bottle standing up	HAUT BAS	44 42	686 607	- -	- -	3 5
Bottle lying down	HAUT BAS	17 13	909 656	24 33	1042 1265	6 1
Bottle upside down	HAUT BAS	20 25	1279 1145	25 21	1109 974	2 1
Parallelepiped standing up	HAUT BAS	- -	- -	41 43	716 725	6 4
Parallelepiped lying down	HAUT BAS	- -	- -	39 41	917 871	8 6

Table 2

Vertical axis: ILNs *haut* (top) and *bas* (bottom). ANOVA with response latency as dependent variable and three factors: entity, positioning, orientation. The two ILNs were grouped together. a) Main interaction effect of the three factors and b) comparisons corrected for multiple comparisons by Fisher's PLSD (Protected Least Significant Difference). S indicates a significant difference at *p* < .05; IT = intrinsic; DT = deictic

a) Main effect:

	df	Sum of Squares	Mean Square	F-ratio	p-value
Interaction	6	17899625	2983270	8.486	<.0001
Résidus	412	144834165	351539		

b) Comparisons:

	Mean Difference (ms)	Difference at p<.05	p-value	
Bottle Lying down DT—Bottle Lying down IT	371	263	.006	S
Bottle Lying down DT—Bottle Up DT	524	201	<.0001	S
Bottle Lying down DT—Bottle Ups. down DT	84	234	.483	
Bottle Lying down DT—Bottle Ups. down IT	-32	234	.788	
Bottle Lying down DT—Paral. Up DT	450	201	<.0001	S
Bottle Lying down DT—Paral. Lying DT	277	201	.007	S
Bottle Lying down IT—Bottle Up DT	152	248	.239	
Bottle Lying down IT—Bottle Ups. down DT	-287	275	.041	S
Bottle Lying down IT—Bottle Ups. down IT	-403	276	.004	S
Bottle Lying down IT—Paral. Up DT	79	250	.535	
Bottle Lying down IT—Paral. Lying down DT	-94	249	.458	
Bottle Up DT—Bottle Ups. down DT	-440	218	<.0001	S
Bottle Up DT—Bottle Ups. down IT	-556	218	<.0001	S
Bottle Up DT—Paral. Up DT	-74	183	.429	
Bottle Up DT—Paral. Lying down DT	-246	183	.008	S
Bottle Ups. down DT—Bottle Ups. down IT	-116	248	.361	
Bottle Ups. down DT—Paral. Up DT	366	218	.001	S

Bottle Ups. down DT—Paral. Lying down DT	194	218	.089	
Bottle Ups. down IT—Paral. Up DT	482	218	<.0001	S
Bottle Ups. down IT—Paral. Lying down DT	309	218	.006	S
Paral. Up DT—Paral. Lying down DT	-173	183	.064	

When the bottle was depicted in its canonical position (Fig. 1a), that is standing up, intrinsic and deictic interpretations overlapped (*haut:* 44, *bas:* 42)[4], response latencies being similar for both ILNs (*haut:* 686 ms, *bas:* 607 ms; t(82)=.89, p<.38)[5].

When the bottle was lying down (Fig. 1b), the choice of a framework to the expense of another resulted in designating different parts of the entity. With an intrinsic framework of reference, it was the neck (*haut*) or the base/bottom (*bas*) of the bottle which was supposed to be pointed to. The deictic framework, which coincided here with the contextual framework (that is gravity), led subjects to identify the top side (*haut*) or the bottom side (*bas*) of the bottle. In such a case, most subjects interpreted *haut* (top) and *bas* (bottom) by means of a deictic strategy (*haut* (top) deictic: 24, intrinsic: 17, eliminated: 6; *bas* (bottom) DT: 33, IT: 13, EL: 1)[6], the repartition between deictic and intrinsic responses observed for these two ILNs being significantly different from a random choice (Chi2(1)=4.32, p<.04). As far as response latencies are concerned, they were shorter for intrinsic interpretations (*haut*: 909, *bas*: 656) than for deictic interpretations (*haut*: 1042, *bas*: 1265), this difference between orientational strategies being here again significant (p<.006).

While, when exposed to a bottle lying down, subjects favoured a deictic strategy, in contrast, when the same item was depicted upside down (Fig. 1c), they increasingly resorted to an intrinsic framework which resulted in the re-balancing of both strategies (*haut* DT: 25, IT: 20, EL:2; *bas* DT: 21, IT: 25, EL:1). The comparison of these results (upside down bottle) with the repartition of responses we got for the lying down bottle

[4] These figures correspond to the number of subjects (out of 47) who chose the same response.

[5] This t-test is presented separately from the global ANOVA in which the two ILNs have been grouped together.

[6] Henceforth, DT stands for deictic, IT for intrinsic and EL for eliminated.

reveals that the observed increase of intrinsic strategies is statiscally significant (Chi2(1)=4.09, p<.05). Although response latencies recorded for the upside down bottle are equivalent for both types of interpretation (*haut* DT: 1109, IT: 1279; *bas* DT: 974, IT: 1145), a pattern emerges from the comparison between the results obtained in the case of the bottlle lying down. It reveals the stability of these response latencies for the deictic interpretation (p<.48) and an increase for the intrinsic interpretation (p<.004). This "functional pattern" was compared with the results recorded for purely geometrical entities (standing up and lying down parallelepipeds). The processing of the ILNs *haut* and *bas* applied to the standing up parallelepiped (*haut* DT: 716; *bas* DT: 725) appears to be very similar to what was noted for the standing up bottle. Indeed, the statistical comparison of these response latencies does not show any significant difference (p<0.43). As concerns the lying down parallelepiped, its comparison with the standing up configuration reveals an increase in response latencies (lying down parallelepiped: *haut*: 917; *bas*: 871) which, even it does not reach significativity (p<.064), seems to suggest that changes in positioning have also an influence in the case of non functional entities. This difference between the two configurations of the parallelepiped is indirectly corroborated by other data from the ANOVA which show that the response latencies corresponding to the lying down parallelepiped and to the standing up bottle are significantly different (p<.008) contrary to the comparison of the latter with the standing up parallelepiped (p<.43).

3.1.3 Commentaries

The strategies adopted by the subjects to identify high/top and low parts of an entity differ and depend on the position of the entity under consideration. Thus, when a bottle is depicted lying down, most subjects choose a deictic interpretation. In contrast, when exposed to an upside down bottle, deictic and intrinsic frameworks are equally activated. Even if the increase in the number of intrinsic interpretations triggered by the turning round of the bottle may first appear paradoxical , it is worth noting that situations in which the bottle is lying and upside down, respectively, are quite different from one another. Indeed, the choice of a deictic or intrinsic framework for the ILN *haut* and *bas* triggers, in the case of a bottle lying down, the designation of four zones spread according to two distinct axes (the intrinsic axis of the bottle and the vertical axis of the subject). In contrast, when the bottle is upside down, the two opposite poles of the same axis are identified (the intrinsic top coincides with the deictic bottom and the deictic top coincides with the intrinsic bottom). In the case of the bottle lying down, the lack of coincidence between deictic and intrinsic frameworks trigger distinct but not "opposite" choices. In contrast, in the case of the upside down bottle, it generates opposite answers. The case of the bottle lying down differs from that where it is upside down in that it adds to the distinct character of possible choices an antagonist dimension, maybe emphasizing the conflictual aspect of the decision-making process.

The three spatial configurations considered in this experiment (standing up, lying down and upside down bottle) also demonstrate a progressive increase in response latencies. This phenomenon illustrates, to a certain extent, the growing complexity of the choices entailed by these three stimuli and confirms that upside down situations are more conflictual than lying down ones. In relation with this latter point on complexity, it is interesting to note that the response latencies collected in the canonical situation (standing up bottle) are equivalent to those obtained when the subject is exposed to an entity deprived of function and which therefore does not display any intrinsic vertical axis (standing up parallelepiped). When entities display pure geometrical shapes and can only be oriented according to a deictic framework (which applies to the case of the parallelepiped), response latencies nonetheless seem to depend partly on the degree of "saliency" or "accessibility" of the designated zones, this accessibility itself depending on the positioning in the space of the geometrical shape . In the case of the parallelepiped standing up (Fig. 1d), the greater geometrical dimension coincides with the gravitational vertical and the top of this entity is a volumic zone which is easily accessible. It is striking to note that in the case of the lying down parallelepiped (Fig. 1e) — its smallest dimension coinciding with the vertical — the top zone is more difficult to access and to designate than in the case of the standing up parallelepiped (given the low extension of the dimension under consideration). These variations in the degree of saliency/accessibility (entailed by changes in positioning) are likely to explain the differences in response latencies observed when comparing the standing up and the lying down parallelepipeds (respectively) with the standing up bottle.

3.2 Frontal axis: geometrical and functional properties

Numerous linguistic and psycholinguistic studies (Clark, 1973; Vandeloise, 1986; Svorou, 1994) have emphasized the essential contribution of functional factors (which are originally essentially anthropomorphic) to the processing of frontal orientation. Thus, C. Vandeloise accounts for the intrinsic frontal orientation of spatial entities by resorting to the concept of general orientation which is in turn based on several properties such as sight, movement orientation or frontal direction. Whether we are dealing with humans or on a broader basis — and by analogy — with spatial entities which surround us, frontal orientation is thus based on functional properties. In this part of the experiment, we intended to test the importance of some functional factors, among which appears that of motion, in the interpretation of the ILN *avant* (front). As in the cases of other ILNs, subjects were presented with various orientations of geometrical shapes in order to be able to assess the influence of functional properties in their choices. First, we show that the processing of the ILN *avant* (front) in cases when subjects are exposed to non functional entities depends on the spatial positioning of the stimuli.

3.2.1 Role of geometrical properties

3.2.1.1 Introduction

As in former parts of our experiment, a parallelepiped was presented in two different positions. In the standing up position (Fig. 1d), the greatest dimension of the parallelepiped coincides with gravitational vertical, the two horizontal dimensions being more or less equal. In the lying down position (Fig. 1e), the largest size of the parallepiped is in the horizontal plane and almost faces the subjects. It is worth noting that in both cases, the geometrical shape was displayed in perspective so that the subjects could perceive its two horizontal dimensions.

Since the entity was deprived of functional properties, the subjects were expected to interpret the ILN *avant* (front) in a deictic fashion. They should thus orientate the geometrical shape by using a "mirror-type" strategy, that is taking into account the part which is located the closest to them (that which faces them) as being the front part. Two possibilities were available to the subjects: in fact, since the geometrical entity was presented to them in perspective, they were provided with the choice between faces which were located to their left and right, respectively.

3.2.1.2 Results

Table 3

Frontal axis: ILN *avant* (front). Mean response latency and number of responses (IT = intrinsic, EL = eliminated)

ENTITY	FRONT RIGHT		FRONT LEFT		EL
	Number	R.T(ms)	Number	R.T(ms)	Number
Parallelepiped standing up	23	1004	19	901	5
Parallelepiped lying down	8	815	32	768	7
House Front Right = IT	34	1043	13	764	0
Bicycle profile Front Right = IT	42	655	-	-	
Bicycle mirror-orientation Front Left = IT	-	-	46	737	1
Bicycle tandem-orientation Front Right = IT	43	695	-	-	4
Dresser Front Left = IT	-	-	44	825	3

In the case of the parallelepiped standing up, the interpretation of the ILN *avant* by subjects showed a relative balance between left and right sides, this repartition of answers being not significantly different from a random choice (front left: 19, front right: 23, EL: 5; Chi2(1)=0.19, p<.8). Response latencies were also equivalent for both types of responses (front left: 901; front right: 1004; t(40)=.55, p<.59)[7].

In the case of the lying down parallelepiped — the largest dimension of which faces the subject — the balance previously reported was lost and most subjects chose the left side of the parallalepiped which was located at the end of the salient dimension, very close to the subject (front left: 32; front right: 8, EL: 7). This dominant character of left side choices is indeed significantly different from a random repartition of responses (Chi2(1)=7.9, p<.005). Response latencies were similar for both choices (front left: 768, front right: 815 , t(38)=.031, p<.97). They are significantly shorter than in the case of the parallepiped standing up (t(80)=2.25, p<.03).

3.2.1.3 Commentaries

In the horizontal perspective subjects favour the most salient dimension — and more exactly one of its ends (the closest to them, since it is a mirror type deictic orientation) — in order to localize the front of the entity. Even if this entity is deprived from functional properties, it does not prevent us from interpreting this choice of the more prominent dimension on the horizontal plane as a direct outcome of the notion of motion which underlies the semantics of the ILN *avant.* In a study of nouns of dimension, C. Vandeloise (1988) describes the various uses of the word *longueur* (length) and points to the probable existence of a "pragmatic bridge" between uses in which it indicates the greatest dimension of an entity on the horizontal plane and those in which it refers to the direction of a mobile entity: "this pragmatic bridge... is based on the aerodynamic character of moving objects. Indeed, an object offers less resistance to air if its longer dimension is parallel to movement". It seems that these remarks confirm

[7]Since only two entities are involved in this section — the standing up parallelepiped and the lying down parallelepiped — differences in response latencies were assessed with unpaired t-test.

the rather close relation entertained by the notion of motion and that of greatest horizontal dimension. However, the front part could be, theoretically, localized at both extremities of this dimension. The fact that subjects choose the extremity of the parallelepiped which is the closest to them confirms that the deictic frontal orientation usually used in French (and more generally in European languages) is based on a mirror strategy rather than in a tandem one (which would lead to point to the farthest extremity) (Hill, 1982).

The strategy adopted by the subjects is also interesting in that it does not constitute the outcome of a strict definition of deictic orientation. Indeed, although the choice of the part of the entity clearly depends on the actual position of the subject, it also considers an internal property of the entity, namely its most prominent dimension in the horizontal plane. This orientation which could appropriately be labelled "deictico-intrinsic" is largely triggered by the presentation in perspective of the geometrical entity and the hesitation in decision-making which it generates regarding the choice of that part of the entity facing the subject. One thus can assume that the subject who would clearly face one of the sides of the parallelepiped (be it the smallest or the largest) would be likely to refer to this particular side when indicating *avant* (front) or *devant* (front surface). The effect produced by the greatest dimension of the spatial entity can also be relativized: this saliency comes from the positioning of the entity, and more precisely from the fact that this dimension is temporarily on an horizontal plane. This is to be contrasted with classical intrinsic features of spatial entities (ex: top of the bottle) which, usually, are not affected by changes of positions.

These remarks about the very nature of the orientation involved in this particular stimulus are closely akin to discussions to be found in many other works (Levinson, 1996; Schober, 1993; Tversky, 1996) concerning the validity and accuracy of the categorizations of orientational processes usually proposed by linguists and psycholinguists (e.g.: distinctions between intrinsic, deictic and contextual orientations).

3.2.2 Role of functional properties

The results of the experiment confirm the relevance of the functional properties in determining the frontal orientation of spatial entities. The following section assesses the functional saliency induced by the layout of the parts of an entity (house) and the role of motion (bicycle).

Table 4

Frontal axis: ILNs *avant* (front). ANOVA with response latency as dependent variable and two factors: entity, orientation. The three positions of the bicycle were grouped together. a) Main interaction effect of the two factors, and b) comparisons corrected for multiple comparisons by Fisher's PLSD (Protected Least Significant Difference). S indicates a significant difference at $p < .05$; IT = intrinsic; DT = deictic

a) Main effect:

	df	Sum of Squares	Mean Square	F-ratio	p-value
Interaction	4	3159577	789894	3.369	.011
Résidus	203	47601994	234492		

b) Comparisons:

	Mean Difference (ms)	Difference at p<.05	p-value	
House DT—House IT	-279	313	.080	
House DT—Bicycle IT	68	278	.629	
House DT—Paral. Lying down Front Right	-51	448	.822	
House DT—Paral. Lying down Front Left	-4	317	.980	
House IT—Bicycle IT	347	187	.0003	S
House IT—Paral. Lying down Front Right	228	397	.260	
House IT—Paral. Lying down Front Left	275	241	.026	S
Bicycle IT—Paral. Lying down Front Right	-119	371	.527	
Bicycle IT—Paral. Lying down Front Left	-72	194	.463	
Paral. Lying down FR—Paral. Lying down FL	47	401	.817	

3.2.2.1 Functional saliency

3.2.2.1.1 Introduction

In order to better measure the contribution of functional properties to the identification of frontal orientation, one of the stimuli used in the experiment required the subjects to localize the front (*avant*) of an entity the functional properties of which are marked, namely a house (Fig. 2a). This spatial entity displayed the following particularity: as far as proportions and positioning are concerned, it was equivalent to the lying down parallelepiped. Thus, the most prominent dimension of this spatial entity was located in its horizontal side and faces the subjects. This house includes a part which may be described as "functionally loaded" — its façade — which coincides with the side displaying the largest horizontal extension (front right side of the paralellepiped). If the subjects only consider salient geometrical properties, they are expected — as in the case of the lying down parallelepiped — to point to the left side of the house (this side being located at the extremity of the largest horizontal dimension: front left/DT). If in contrast, they rely on functional and structural properties of the entity in order to identify the most salient part, they are expected to point to the right side of the house (front right/IT).

3.2.2.1.2 Results

Most subjects (about 2/3) considered that the front of the house corresponds to its façade (right side). The other subjects pointed to the left side of the entity (front left/DT: 13, front right/IT: 34). This repartition of responses between intrinsic and deictic strategies is different from random (Chi2(1)=4.98, $p<.03$). The intrinsic (front right) or deictic (front left) interpretations of the ILN *avant* generated response latencies which were longer in the former case than in the latter (front IT: 1043, front DT: 764). However, this difference is not significant ($p<.08$). Moreover, the response latency triggered by the deictic front (left front) of the house is similar to that which applies to the identification of the left side of the lying down parallelepiped (768), the observed difference being nonsignificant ($p<.98$). On the contrary, response latencies corresponding to the left side of the lying down parallelepiped are significantly different from the results gathered for the intrinsic front (right front) of the house ($p<.026$).

3.2.2.1.3 Commentaries

According to the above results, a pattern of intrinsic interpretation seems to emerge: the internal properties of a functional entity generate an inversion of the results obtained for the lying down parallelepiped, and this applies in spite of the numerous geometrical similarities shared by both the parallelepiped and the house. The analysis of orientational phenomena sometimes draws a distinction between a positional orientation which considers the use we make of entities (ex: when one opens a wardrobe, one faces its doors) and an anthropomorphic orientation which, in contrast, identifies the most functionally loaded part of an entity (by analogy with the human body). Although these two notions are closely related (the most functionally loaded part being typically that with which one interacts), substantial diachronic data suggest that anthropomorphic orientation is more fundamental and primary (Vandeloise, 1986). In the case of the house, it seems that the layout of the various parts and their strong concentration on one of the sides (rather than the very functional use or positional orientation) constitute very important criteria for the subjects who identify the intrinsic front.

As we have already underlined, the apparent differences between response latencies entailed by intrinsic (right side/façade: 1043) and deictic (left side: 764) interpretations of the ILN *avant* are not statistically significant. This is probably due to the existence of great interindividual variations when localizing the front part of the house. Besides, a relative stability of response latencies needed for deictic interpretations was observed when comparing the designation of the left side in both the case of the house and the lying down parallelepiped. This observation may lead to wonder whether every subject really take into account all the possible strategies (deictic/intrinsic) for interpreting the ILN *avant*. We could argue that, in the case of the house, some subjects (deictic ones ?) mainly ground their choice on geometrical parameters, forgetting in some way the functional interpretation. This may explain the stability noted for deictic interpretations of *avant* across the stimuli under consideration as well as the differences observed in relation with the left side of the parallelepiped (deictic) and the right side of the house (intrinsic). In any case, it appears that supplementary tests are required in order to clarify this point. The localization of the house front in a display with horizontally equal dimensions (as in the parallelepiped standing up) should definitely be included in the protocol. This would enable us to neutralize the geometrical factor involved in the former stimulus.

3.2.2.2 ILN *avant* (front) and the concept of motion

3.2.2.2.1 Introduction

As the studies carried out by C. Vandeloise have demonstrated, the semantics of the preposition *avant* (front) is closely related to the notion of motion. This is particularly obvious in those utterances which describe the trajectory adopted by spatial entities (Asher et al., 1995).

As a consequence, the parts designated by the ILNs *avant* (front) and *devant* (front surface) do not only differ in their dimensionality (as other couples of ILNs do (e.g.: *haut* (top)/*dessus* (top surface)): volume versus surface) but also in the role that the notion of motion plays in their semantic content.

If, in line with such an hypothesis, the semantics of the ILN *devant* (front surface) depends less on the concept of motion than that of *avant* (front), these two lexical elements should generate different types of processing when applied to identical static entities. In particular, one would expect to get faster response latencies for *devant* than for *avant* (because, according to the previous assumption, the absence of motion may be a problem for the latter but not for the former). These possible differences in the semantics of *avant* and *devant* (when applied to static entities) were first tested for the previously mentioned house. These two ILNs were also compared with another kind of static entity, namely a dresser facing the subject (Fig. 2b) for which the intrinsic and deictic interpretations of frontal orientation coincide.

In order to better grasp the possible contribution of motion to the semantics of *avant*, we introduced in the task a mobile entity (a bicycle). This spatial entity was exposed to the subjects' judgements under three distinct perspectives: profile positioning (Fig. 2c); facing the subject, that is in a mirror-type orientation (Fig. 2d), and oriented in tandem (Fig. 2e). Following the previous assumption about the role of motion in the semantics of *avant*, our aim, here, was to verify whether the response latencies were faster for the bicycle than for a static entity.

3.2.2.2.2 Results

In the case of the house, the response latencies recorded for the designation of the front surface — *devant* (DT: 690, IT: 873) — are shorter than those required to indicate the front — *avant* — and this difference is significant (paired t-test $t(44)= 1.73$, $p<.05$).

<u>Table 5</u>

Frontal axis: ILN *devant* (front surface). Mean response latency and number of responses (IT = intrinsic, DT = deictic, EL = eliminated)

ENTITY	IT		DT		EL
	Number	R.T(ms)	Number	R.T(ms)	Number
Dresser	41	780	-	-	6
House	36	873	10	690	1

In the case of the dresser, and even if the processing of *devant* seems, here again, to be less costly than the processing of *avant* (*avant* IT: 825, *devant* IT: 780), such a tendency is not statistically significant ($t(83)=.4$, $p<.65$).

Thus, the use of *avant* and *devant* with static entities does not seem to provide stable clues susceptible to corroborate the role of motion in the semantics of the former lexeme. From this point of view, the results obtained for the bicycle and their comparison with a static configuration (the house) turned out to be more illustrative of such a role.

No matter which positioning of the bicycle is under consideration, subjects carried out an intrinsic interpretation of the ILN *avant* (front) by pointing to the part which is typically facing the direction of motion and which includes, among other components, handlebars (profile IT: 42, EL: 5; mirror IT: 46, EL: 1; tandem IT: 43, EL: 4). Response latencies obtained for these three types of configurations were very similar (profile IT: 655, mirror IT: 737, tandem IT: 695) and a two by two comparison of these results confirmed that the observed differences are not significant. The ANOVA revealed that the mean response latency obtained from the three positions of the bicycle is shorter than the response latency corresponding to the intrinsic *avant* (front) of the house ($p<.0003$). Moreover, the separate comparisons of the three positions of the bicycle with the results entailed by the house (intrinsic + deictic front) confirmed the differences in response latencies between these two kinds of entities (house/profile bicy.: $t(41)=4.11$, $p<.0002$; house/mirror bicy.: $t(41)=2.94$, $p<.0054$; house/tandem bicy.: $t(41)=4.31$, $p<.0001$)[8]. On the contrary, the processing of the ILN *avant* applied to the bicycle entailed response latencies which were very similar to those we got for the lying down parallelepiped, the statistical comparison of these two situations having not revealed any significant difference ($p<.46$). So, the latter entity (lying down parallelepiped) is, in terms of processing costs, much closer to a mobile entity such as a bicycle than to a static one (house).

[8]Differences were tested with paired t-test. Such differences remain valid when comparing the results obtained for the different positions of the bicycle with the sole intrinsic *avant* (front) of the house.

3.2.2.2.3 Commentaries

If the "pragmatic bridge" which exists between the notion of motion and that of greatest horizontal dimension (lying down parallelepiped) is taken into account, it can be observed that the response latencies recorded when pointing to the front (*avant*) are all the faster when the entity is mobile or related to the concept of motion (house > lying down parallelepiped/bicycle). Indeed, one could argue that the different response latencies obtained for the bicycle and the house could be simply explained by the fact that the front part is more salient in the former situation than in the latter one. However, it seems that such an analysis in terms of the sole saliency would not allow to account satisfactorily for the case of the lying down parallelepiped whose processing appears to be much closer to that of the bicycle than to that of the house. In our opinion, the salient character of the frontal axis is much higher when the considered spatial entity is conceptualized as functionally moving along this direction, so that saliency seems to be indirectly conditioned by the mobile/static character of entities. This is probably the case for the bicycle, where the saliency of the front part is so strong that the deictic interpretation of the ILN *avant* seems to be excluded whatever the proposed positioning (bicycle positioned in profile, in a mirror-type position or in tandem). These data validate, to some extent, the contribution of motion to the semantics of the ILN *avant*. However, a more detailed analysis of the role played by this notion may need to introduce further mobile entities in the experiment. In particular, it should be necessary to consider mobile objects being geometrically similar to the house (parallelepipedic entities like trucks, carts, cars, other vehicles) in order to reduce the possible effect of shape (linear entities (bicycle)/volumic entities (house)) and to focus more directly on the part played by motion.

3.3 Lateral axis

3.3.1 ILNs *droite* (right) and *gauche* (left)

3.3.1.1 Introduction

The localization of the left and right poles requires the definition of lateral directions. Although spatial entities and their environment provide objective criteria to define precisely vertical and frontal orientations (gravity for the former and eye orientation and movement for the latter), the definition of lateral orientation cannot rely on such strong criteria. Klein (1983) presents a definition based on the speakers' eye orientation whereas Vandeloise (1986) resorts to a notion of lateral direction materialized, for instance, by the spatial position of the shoulders. Vandeloise still points to the fact that lateral orientation can also be characterized on the basis of its perpendicular positioning in relation to general orientation (which in turn relies on frontal direction, sight and movement). In a canonical situation, lateral orientation is thus parallel to lateral direction and perpendicular to the landmark general orientation (which then coincides with frontal direction). The difficulty found in attempting to account for the notion of lateral orientation clearly emphasizes its complexity[9]. Since it is an inherently anthropomorphic concept, it is not surprising that most entities displaying intrinsic lateral orientation refer to animates.

Subjects facing an entity can locate its left and right pole in two ways. They may first consider that the left pole (respectively the right pole) of the entity and their own left (respectively their own right) are localized in the same side. Another possibility consists in locating the left pole (respectively the right pole) of the entity in the zone adjoining their own right (respectively their own left). In the former case, a coincidence between the lateral orientation of the subjects and that of the entity emerges while in the latter case an opposition between both orientations is found. This phase of our study aims at appraising to which extent the entity's functional properties — and more specifically the way in which it is used — may affect the type of lateral orientation selected (“ coincidence strategy ” — henceforth CO — versus “ opposition strategy ” —

[9]This complexity is also illustrated by the fact that — beyond the sole identification of the lateral axis of an entity — the localization of right and left poles (indirectly) implies to calculate both frontal and vertical orientations.

henceforth OP —).

Subjects were exposed to an object which could be used in mirror (wardrobe) and an object to be used in tandem (armchair) and were asked to indicate the left and the right side. Both entities were depicted in a position which made them adopt the same frontal and vertical orientations in relation to the subject, in order to avoid the effect of a difference due to these axes (Figs. 3a & 3b). A third object — neutral as far as its use is concerned (standing up parallelepiped) and without any obvious frontal orientation — was presented with the same instructions. This object is used as a reference in the interpretation of the results. A high number of responses of the type CO was expected for the parallelepiped (by direct transfer of the subjects' orientation) and a higher number of responses of the same type for the wardrobe than for the armchair. Indeed, and because of the tandem type use, more subjects were expected to (virtually) make their frontal orientation coincide with that of the entity facing them for the armchair than for the wardrobe— thereby assigning it a lateral orientation opposite to theirs —.

3.3.1.2 Results

Table 6

Lateral axis: ILNs *droite* (right) and *gauche* (left). Mean response latency and number of responses (CO = coincidence, OP = opposition, EL = eliminated)

ENTITY	ILN	CO		OP		EL
		Number	R.T(ms)	Number	R.T(ms)	Number
Parallelepiped standing up	DROITE GAUCHE	38 37	1012 1076	7 8	1380 1474	2 2
Wardrobe	DROITE GAUCHE	32 36	842 910	11 11	1095 1017	4 0
Armchair	DROITE GAUCHE	30 32	884 901	14 13	1027 1011	3 2

Table 7

Lateral axis: ILNs *droite* (right) and *gauche* (left). ANOVA with response latency as dependent variable and two factors: entity, orientation. The two ILNs were grouped together. a) Main interaction effect of the two factors, and b) comparisons corrected for multiple comparisons by Fisher's PLSD (Protected Least Significant Difference). S indicates a significant difference at *p* < .05; CO = coincidence; OP = opposition

a) Main effect:

	df	Sum of Squares	Mean Square	F-ratio	p-value
Interaction	5	3687838	737567	2.136	.061
Résidus	259	89446133	345351		

b) Comparisons:

	Mean Difference (ms)	Difference at p<.05	p-value	
Wardrobe CO—Wardrobe OP	-68	284	.639	
Wardrobe CO—Armchair CO	42	203	.686	
Wardrobe CO—Armchair OP	-85	263	.527	
Wardrobe CO—Paral. Up CO	-108	196	.277	
Wardrobe CO—Paral. Up OP	-492	340	.005	S
Wardrobe OP—Armchair CO	109	287	.453	
Wardrobe OP—Armchair OP	-17	332	.920	
Wardrobe OP—Paral. Up CO	-41	282	.777	
Wardrobe OP—Paral. Up OP	-424	396	.036	S
Armchair CO—Armchair OP	-126	267	.351	
Armchair CO—Paral. Up CO	-150	200	.141	
Armchair CO—Paral. Up OP	-534	342	.002	S
Armchair OP— Paral. Up CO	-24	261	.859	
Armchair OP—Paral. Up OP	-407	381	.036	S
Paral. Up CO—Paral. Up OP	-384	338	.026	S

The parallelepiped was oriented by some subjects (7 for *droite* (right) and 8 for *gauche* (left)) in a way opposite to their lateral orientation (OP strategy). The cost in response latencies for these subjects was higher than for subjects who adopted a deictic orientation (1380-1012 for *droite* (right) and 1474-1076 for *gauche* (left)) and the ANOVA indicated that such a difference is significant ($p<.026$). On the whole, the time spent to assess the right and the left of a neutral object was longer than that required by the processing of functional entities, when subjects predominantly choose an OP strategy (parallelepiped versus wardrobe: $p<.036$; parallelepiped versus armchair: , $p<.036$) .

Moreover, 4 subjects adopted the opposite orientation (OP strategy) for both *gauche* and *droite.* The coherence which characterizes the responses probably reflects the existence of interindividual variability — in cognitive styles ? — in the way to perceive laterality, an issue that further studies will have to address in a more systematic way.

In relation to the object which can be used in mirror (the wardrobe), the opposite orientation was chosen by 11 subjects for the right as well as the left side. For the object which can be used in tandem, these figures went up to 14 for the left and 13 for the right. No matter whether the instruction refers to left or right, response latencies in the case of opposition strategies (OP) on the one hand, and those corresponding to responses of the “ coincidence ” type (CO) on the other hand were equivalent (Wardrobe: $p<.64$; Armchair: $p<.35$). The increase in OP/CO ratio (Parall.: 15/75; Wardrobe: 22/68; Armchair: 27/62) suggests a prominence of the OP type responses for objects which can be used in tandem (Parallelepiped versus Wardrobe: $\chi^2(1)= 1.66$, $p<.2$ N.S.; Parallelepiped versus Armchair: $\chi^2(1)= 4.66$, $p<.04$).

3.3.1.3 Commentaries

It would indeed be worth comparing those results with those of an experiment in which the subjects would be instructed, for instance in the case of the wardrobe, to reach an object on the right, providing them with the choice between two objects, one being placed on the right, the other on the left. The fact that 7 subjects adopt an opposite orientation when exposed to an object such as the parallelepiped (when no ambiguity is raised by the vertical orientation) demonstrates the extent to which lateral orientation is difficult to apprehend. Indeed, subjects wonder as to which strategy they should adopt even when exposed to neutral objects. This result is surprising since it is generally assumed that, when deprived of intrinsic frontal orientation, the subject's own laterality applies. We must not overlook the fact that the functional character of an entity (canonical interaction with that entity) yields a decrease in the time spent on selecting a strategy.

Beyond experiments in a real situation, these results suggest an extension of the same pointing task (left/right) to other types of entities, especially those which display mirror type uses (e.g. a TV set, a computer, etc.). In fact, it is not until the attitude of subjects confronted with a substantial number of entities is observed that the actual influence of functional factors on lateral orientation assignment can be appraised. This extension, applied to other types of entities, will also make it possible to explore the exact nature (intrinsic/deictic) of the assigned orientation. Thus, it seems clear that cases of lateral orientation opposite to that of the subject (e.g. the armchair) are best captured as instances of intrinsic orientation. In contrast, other cases of coincidence mentioned above are not so clear. When the entity presented to the subject displays a geometrical shape (parallelepiped), the lack of any functional properties warrants the deictic character of the lateral orientation involved. In contrast, for entities used in mirror (e.g. the wardrobe), the lateral orientation which coincides with that of the subject does not necessarily imply that it is deictic. In fact, a canonical interaction in mirror with the entity may have induced the subjects to assign to this entity an intrinsic left and an intrinsic right which then coincide with the left and right of a subject facing it. One way of testing the intrinsic or deictic nature of these "coincident" lateral orientations could consist in exposing the subjects to the back part of the functional entity under consideration and asking them to point to the left or to the right side. If the lateral orientation of the type coincidence used by the subjects when they face the entity truly pertains to its intrinsic nature, the same subjects facing the back of this entity should be able to point to the part located on their right as the left side.

3.3.2 Polysemy of the ILN *côté* (side)

3.3.2.1 Introduction

According to Leech (Leech, 1969), the ILN *côté* (side) may give rise to three interpretations, which progress from most restrictive to most general, when referring to a (prototypical) parallelepipedic entity:

- restrictive interpretation: one of the 2 lateral sides
- half-way interpretation: one of the 4 vertical sides (lateral sides, front and back sides)
- broad interpretation: one of the 6 sides

These interpretations correspond to a progressive broadening of the meaning of the ILN *côté* (side). This ILN derives from the noun of component *côte* (rib) which was originally used to refer to the lateral sides of an entity, after which its use was extended to the reference of all types of sides. It is relevant to note that the prepositional phrase *à côté de* (at the side of/next to/near) may be used to localize a trajector in relation to the lateral zones which define a landmark as well as to localize a trajector in an area surrounding a landmark. Such a phenomenon of extension is not particularly striking: it has been found in other languages and on other ILNs. For instance, (Svorou, 1994) mentions the fact that spatial markers which originally referred to the front (*avant*) or the back (*arrière*) have had their uses progressively generalized to also indicate the zone surrounding these entities.

The choice of one of the three interpretations described above as opposed to another is likely to depend on the nature of the object under consideration. Our hypotheses are that

- the strictest interpretation is accurate when applied to strongly lateralized objects
- the interpretation broadens as the degree of lateralization decreases.

Three objects have been selected, each of which being liable to yield a different interpretation:

- a car depicted in a 3/4 profile (Fig. 3c)
- an horizontal square section vase (Fig. 3d)
- a dice (Fig. 3e).

According to our hypotheses, a restrictive interpretation applies to the car since it displays a strong lateralization due to the internal layout of its various parts (lights, windscreen, doors), to its long shape and to the direction of its movement. The vase is less lateralized than the car since its four vertical faces do not display features which enable us to distinguish them while its top has a distinct function (side through which the flowers come out). To the dice — three sides of which can be seen (top side, frontal side and right lateral side) — is to be applied the broader interpretation since its 6 sides fulfill the same function and display the same shape.

3.3.2.2 Results

Table 8
Lateral axis: ILN *côté* (side). Mean response latency and number of responses (LS: lateral side, FS: front side, EL: eliminated)

ENTITY	LS		FS		EL
	Number	R.T(ms)	Number	R.T(ms)	Number
Car in 3/4 profile	41	907	0	-	6
Vase	21	1399	14	1209	12
Dice	30	1040	9	857	8

Results indicated that the car's lateralization triggers the most restricted interpretation of the ILN *côté* (41 responses); the zone to which subjects pointed is best captured as the intrinsic side. When exposed to the vase, subjects (14 out of 35; significantly different from 0/41: Chi2(1)= 8.75, p<.0001) pointed to the non-lateral vertical side: this clearly demonstrates that they chose the second interpretation described above (the so-called “ half way interpretation ”). Out of the 21 subjects left who chose the lateral side, the fact that some of them also chose the second interpretation of the ILN *côté* should not be overlooked (because the sides pointed out in each of the three interpretations are organized in an inclusive way: restrictive interpretation ℘ half-way interpretation ℘ broad interpretation).

In line with our hypotheses, the third interpretation which should have been triggered by the dice was adopted by none of the subjects. The results obtained for this entity show that the standard deviation for LS (lateral side) responses (819 ms) is the highest value (compared to car or vase or even to Dice FS (front side) responses: 460 ms). This suggests a bimodal distribution. Indeed, a cluster analysis of responses time shows two separate clusters (cluster1: minimum: 256 ms, maximum: 863, mean: 548, number: 17; cluster2: minimum: 1058 ms, maximum: 3397, mean: 1683, number: 13).

3.3.2.3 Commentaries

The restrictive and half-way interpretation of ILN *côté* were successfully evidenced by the car and the vase respectively. The third interpretation was not triggered by the dice. It thus seems that the lack of functional lateralization does not suffice for the ILN *côté* to reach its broader meaning. Since the figures printed on the sides of the dice were different, it is legitimate to wonder whether this effect introduces some kind of dissymetry or difference between faces which could account for the results. A cube would probably have been better adapted to test the broad interpretation since it would have warranted a better equivalence between the various sides.

However, a deeper observation of the results recorded for the dice indicates that subjects who pointed to the lateral face may be divided into two roughly equal sub-populations. The first group which is characterized by a low average response latency (548 ms) probably relate to those subjects who chose a middle or broad interpretation of the ILN *côté*. In the case of the second group, the average response latency is much higher (1683 ms). Thus, one may suppose that the subjects who carried out such performance chose a narrow interpretation of the ILN, which, as mentioned above, seems to give rise to a temporally more costly processing. This additional cost is probably due to a greater difficulty to identify the lateral orientation *when functional* *properties are lacking* (note that in the case of the car the lateral side is identified more quickly).

4 General discussion: comparison of the three axes

After discussing separately the results obtained for each axis (vertical, frontal and lateral), we try to make comparisons between these different kinds of orientational ILNs. The comparison concerns both the observed variations of response latencies and the distinctive properties which characterize these orientations.

4.1 Response latencies according to the three axes in the absence of intrinsic orientation

In order to investigate across ILN differences (in terms of response latencies) according to the three axes of orientation (vertical, frontal and lateral), we have considered the parallelepiped in cases in which it is depicted standing up which dramatically reduces the possibilities of intrinsic orientation. An ANOVA with response latency as dependant variable and one factor with 3 levels (vertical, frontal, lateral) was conducted (see Table 9).

Table 9

Comparisons of the three axes for the standing up parallelepiped. ANOVA with response latency as dependent variable and one factor with three levels: vertical (*haut*/top + *bas*/bottom), frontal (*avant*/front), and lateral (*droite*/right + *gauche*/left). a) Main effect and b) comparisons corrected for multiple comparisons with Fisher's PLSD. S indicates a significant difference at *p* < .05

a) Main effect:

	df	Sum of Squares	Mean Square	F-ratio	p-value
Axis	2	6224470	3112235	10.029	<.0001
Résidus	205	63615064	310317		

b) Comparisons:

	Mean Difference (ms)	Difference at p<.05	p-value	
Vertical—Lateral	-385	170	<.0001	S
Vertical—Frontal	-236	210	.028	S
Lateral—Frontal	149	208	.159	

The results show that the vertical axis is to be distinguished from the two others: 721 ms (averaged from *haut* (top) and *bas* (bottom)). This mean response latency is indeed significantly shorter than the mean latencies obtained for both the frontal (*avant* (front): 967 ms; p<.03) and lateral axes (1105 ms: averaged from *droite* (right) and *gauche* (left); p<.0001). Although these data seem to also suggest that the processing of ILNs is less costly for the frontal axis (967 ms) than for the lateral one (1105 ms), such a difference seems to not reach significativity (p<.16).

These differences in the processing of orientational axes mainly coincide with observations made in other works about spatial expressions and orientation (Franklin & Tversky, 1990; Piérart, 1979).

4.2 Response latencies on intrinsic and deictic orientations

The comparison between deictic and intrinsic processing of ILNs, on the basis of the whole set of spatial entities for which this choice is possible, does not show any systematic differences. Whereas, for some stimuli, the processing time of the intrinsic response is shorter than that of the deictic one, for others the reverse pattern applies. In the case of a bottle lying down, the processing times are shorter for the intrinsic interpretation than for the deictic interpretation, especially for the ILN *bas* (bottom). In contrast, in the case of the house depicted in perspective, it is the deictic interpretation *avant* (front) which is less costly in response latency than the intrinsic interpretation.

4.3 Correlation between the frontal and lateral axes

When exposed to the ILN *gauche* (left) and *droite* (right) and to the parallelepiped standing up, subjects apply to this spatial entity a lateral orientation — coinciding with their own orientation (CO) or opposite to it (OP) — which makes it necessary to resort to a frontal axis perpendicular to the edge of the parallelepiped which faces them. This definition of the frontal axis cannot be applied in the identification of the ILN *avant* (front) since, as described above, subjects choose in this case a frontal orientation perpendicular to one of the two sides. Thus, it appears that the frontal axis is not defined in the same way when this axis constitutes a mere "intermediary stage" in the interpretation (former case) and when it is directly involved in the pointing task (latter case). These remarks illustrate the differences existing between strategies involved for the identification of an axis depending on whether this identification is carried out in a conscious fashion (directly governing the semantics of the considered ILN, e.g.: frontal orientation and *avant* (front)) or whether it constitutes an intermediary process carried out in an unconscious or automatic fashion (indirectly related to the semantics of the marker, e.g.: frontal orientation and *gauche* (left)/*droite* (right)). This type of differential processing will be the focus of further studies from our group.

4.4 Multiple response situations and “ processing conflicts ”

We have observed that for numerous spatial entities endowed with functional properties, ILN processing could trigger the designation of different zones depending on the subjects' interpretation of this marker (regarding orientational ILNs, these interpretations essentially relie on the kind of orientation — intrinsic/deictic — chosen). A detailed observation of these multiple response stimuli enables us to distinguish two specific types of situations. In some cases, some responses may require less “ computations ” than others. This seems to be the case, for instance, for the intrinsic top of a bottle lying down, the deictic front of a house, or else the non lateral interpretations of the ILN *côté* (side) when referring to a dice. Besides, some situations occur in which the range of possible responses require longer delays. Such increases were appraised by comparing the recorded delays to those corresponding to stimuli in which the same spatial entity is depicted in different conditions. This was observed, for instance, in the cases of the ILN *haut/bas* (top/bottom) and of an upside down bottle, or else in the case of the ILN *côté* (side) relating to the vase.

Beyond the sole observation of the generalized increase of response latencies, it is relevant to wonder about the factors of such conflictual situations. In other words, in which conditions various possible interpretations of a same ILN come to be opposed to one another? The data collected on the bottle may partly provide a provisional answer. We must recall that both orientational strategies (i.e deictic and intrinsic) involved in the case of the ILN *haut/bas* (top/bottom) applied to the lying down bottle generate distinct — but not opposite — responses (organized according to two perpendicular axes). In this case, response latencies are shorter for intrinsic than for deictic interpretations. As far as the upside down bottle is concerned, both types of orientations (deictic and intrinsic) resort to identical axes. Therefore, intrinsic *haut* /deictic *bas*, on the one hand, and intrinsic *bas*/deictic *haut,* on the other hand coincide. Moreover, there is an overall increase in response latencies. The conflictual aspect found here constitutes the outcome of the coincidence of those zones identified by the ILN *haut/bas* (top/bottom) contrasted with the opposite semantic contents of these two spatial markers. It is as if the designation of the top of the spatial entity could not be performed overlooking the fact that the identified zone could also be designated by *bas* (bottom). This could be an explanation for the difficulty in decision making as well as for the increase in response latencies. In contrast to conflicting factors, situations in which at least one response requires less computation than the others may suggest that the whole set of possible interpretations or responses is not taken into account. If this hypothesis is correct — i.e. if only a partial scanning of possible choices or strategies is performed by the subject — , it will have to be further assessed through the identification and the characterization of responses which give rise to this type of phenomena. In a first approximation, it seems that in the case of the lying down bottle and of the ILN *bas* (bottom) , the intrinsic interpretation is more quickly accessed whereas in the case of the house and the ILN *avant* (front), the least costly interpretation is the deictic one. The variability of the response latencies recorded for some multiple response situations suggests another remark. It should not be overlooked that the fastest responses correspond to precalculated or "tuned in" information involving both language and perception (Borillo M. & Pensec, 1995) and whose access is therefore less costly. Conversely, those longer response latencies would correspond to data which require each time a new mental computation. In any case, the analysis of multiple response conditions raises problems which should be thoroughly investigated in future studies. One orientation may consist in defining a precise computational framework in which the complexity of formal definitions of ILNs could be used to appraise the “ theoretical ”, or expected response times.

5. Conclusion

This experiment opens new avenues for the descriptive and formal research on spatial markers which are very often grounded — particularly in the linguistic literature — on an introspective approach only. Although it is at the expense of a simplification of the linguistic message presented to the subjects, we showed that it is possible to grasp the specific role that several functional and contextual/pragmatic properties play in the interpretation of orientational ILNs. Functional aspects include factors such as saliency of a part, motion, canonical interaction, degree of lateralization while contextual features are mainly concerned with the influence of positioning. Beyond the mere confirmation of the part played by non-geometrical factors in the interpretation of ILNs, our data are in accordance with several important assumptions put forward by the theories of linguistic space (among which the influence of motion in the semantics of *avant* (front)).

The first characterization of multiple response situations and the hypothesis according to which the subjects do not always take into account the entire range of interpretations of an ILN (opposition between conflictual and non conflictual situations) also seem to open promising research lines, from a psycholinguistic point of view, on the processing of these lexemes by the human mind. This facet of our work will obviously need to be complemented by across subjects comparisons in order to determine the possible existence of distinct cognitive profiles in the processing of such entities.

Thus, in our view, the results of this study are likely to contribute to both the linguistic works in lexical semantics — of which they constitute a "natural" complement — and the psycholinguistic studies of spatial cognition.

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